

CLAIMS

1. A tube bundle apparatus suitable for efficiently effecting the thermal exchange, under high pressure and temperature conditions, between at least two fluids of which one has highly aggressive characteristics under the process conditions, comprising a hollow body equipped with an external casing, or pressure-resistant body, suitable for tolerating the operating pressures and consisting of a material subject to corrosion by contact with said highly aggressive fluid, and appropriate openings for the entrance and exit of the fluids, inside which there are at least two cavities separated from each other by a third sealed cavity with respect to these, situated between two septa or plates hinged onto the pressure-resistant body, said two cavities communicating with each other by means of a series of tubes, whose internal wall is put in contact with said highly aggressive fluid and consists of a material selected from titanium, zirconium or an alloy of one of these which is highly resistant to corrosion, forming a tube bundle situated between said two septa or plates which passes through said third cavity, characterized in that at least one of said two cavities is

in contact with said highly aggressive fluid and is at least partly delimited by a wall comprising at least three metallic layers consisting of:

- 5 A) an external layer suitable for tolerating the pressure load, subject to corrosion by contact with said highly aggressive process fluid;
- B) an intermediate layer made of stainless steel;
- C) an anticorrosive lining in contact with said highly corrosive fluid, consisting of a material
10 selected from titanium, zirconium or an alloy of one of these.
2. The apparatus according to claim 1, wherein said material forming the lining C is selected from titanium and zirconium, preferably zirconium.
- 15 3. The apparatus according to one of the claims 1 or 2, positioned vertically, wherein said cavity bordered by three layers forms the lower collection chamber of the highly aggressive fluid.
4. The apparatus according to any of the previous
20 claims, wherein said three-layered wall completely borders the cavity in contact with the highly aggressive fluid.
5. The apparatus according to any of the previous
25 claims, wherein said layer B has a thickness ranging from 3 to 25 mm and said layer C has a thick-

ness ranging from 0.5 to 10 mm.

6. The apparatus according to any of the previous claims, wherein said layer B consists of a stainless steel selected from AISI 316L steel, INOX
5 steels, special austenitic-ferritic steels.
7. The apparatus according to any of the previous claims, wherein said layer C is at least partially obtained by means of a welding deposit.
8. The apparatus according to any of the previous
10 claims, wherein said layer C is obtained by means of the thermal spray technology.
9. The apparatus according to any of the previous claims, comprising weep-holes situated in the pressure-resistant body.
- 15 10. The apparatus according to any of the previous claims, wherein each tube in said tube bundle is a bimetallic tube comprising a stainless steel outer layer and an internal lining layer, in contact with the corrosive fluid, consisting of a material
20 selected from titanium, zirconium or an alloy of one of them.
11. The apparatus according to the previous claim 10, wherein, in said bimetallic tube, the ratio between the thickness of said stainless steel outer
25 layer and said internal lining layer ranges from 1

to 20.

12. The apparatus according to the previous claim 11,
wherein, said outer layer has a thickness of from
2 to 15 mm, and said internal layer has a thick-
5 ness of from 0,5 to 3 mm.

13. The apparatus according to any of the previous
claims from 10 to 12, wherein said layer B con-
sists of the same material as the external layer
of said bimetallic tube and said layer C of the
10 same material as the internal lining of said
bimetallic tube.

14. The apparatus according to any of the previous
claims from 10 to 13, wherein said wall comprising
at least three metallic layers constitutes at
15 least the plate delimiting said cavity in contact
with the highly aggressive fluid.

15. The apparatus according to the previous claim 14,
wherein said B layer is strength and seal welded
with the stainless steel layer of said bimetallic
20 tubes, and said C layer is seal welded with the
internal layer of said bimetallic tubes.

16. The apparatus according to any of the previous
claims from 1 to 9, wherein each tube of said tube
bundle entirely consists of a metal selected from
25 titanium, zirconium or an alloy of one of them.

17. The apparatus according to the previous claim 16,
wherein the average thickness of said tube ranges
from 3 to 5 mm.
18. The apparatus according to any of the previous
5 claims 16 and 17, wherein said wall comprising at
least three layers constitute at least the tube
sheet plate delimiting said cavity in contact with
the highly corrosive fluid.
19. The apparatus according to the previous claim 18,
10 wherein, in said plate, said layer C is strength
and seal welded to each of said tubes and has a
thickness ranging from 2 to 10 mm.
20. The apparatus according to any of the previous
claims from 16 to 19, wherein a further carbon
15 steel layer D is inserted between said layers B
and C, said layer having a thickness ranging from
2 to 10 mm.
21. Use of the apparatus according to claims 1 to 20
in a plant for the synthesis of urea.
- 20 22. The use according to the previous claim 21, as
stripper in the high pressure synthesis cycle.
23. A method for the manufacturing of a tube bundle
apparatus according to any of the claims from 1 to
20, comprising in succession:
- 25 - the construction of a hollow body equipped

with an external casing, or pressure-resistant body, appropriate for tolerating the operating pressures and consisting of a material subject to corrosion by contact with
5 said highly aggressive fluid;

the formation, inside said hollow body of at least two cavities separated from each other by a third sealed cavity with respect to these, by the interpositioning of at least
10 two plates, or septa, hinged to the pressure-resistant body, on which, to put said cavities in communication with each other, a series of tubes is inserted, forming a tube bundle, whose internal wall consists of a ma-
15 terial selected from titanium, zirconium or an alloy of one of these, highly resistant to corrosion, so that during use, said internal wall of the tubes and the wall of at least one of said two cavities is in contact with
20 said highly aggressive fluid;

said method being characterized in that the wall which delimits at least one of said cavities is at least partly produced by superimposing the following three metallic layers in order:

25 A) an external layer suitable for tolerating the

pressure load, subject to corrosion by contact with said highly aggressive process fluid;

B) a stainless steel intermediate layer;

C) an anticorrosive lining situated on the internal surface in contact, during use, with said highly corrosive fluid, consisting of a material selected from titanium, zirconium or an alloy of one of these.

24. The manufacturing method according to the previous claim 23, wherein the wall of said cavity in contact with the highly aggressive fluid is entirely produced by superimposing said metallic layers A, B and C.
25. The manufacturing method according to any of the previous claims 23 and 24, wherein said layer C consists of zirconium.
26. The manufacturing method according to any of the previous claims from 23 to 25, wherein said cavity delimited by a three-layered wall A, B and C forms the lower chamber of a stripper.
27. The manufacturing method according to any of the previous claims from 23 to 26, wherein said layer C is deposited in close contact with said layer B by means of a thermal spray technique.
28. The manufacturing method according to the previous

claim 27, wherein said thermal spray technique is used in the area of the tube sheet plate.

29. The manufacturing method according to any of the previous claims 27 or 28, wherein said thermal spray technique is a spray arc technique.
30. The manufacturing method according to any of the previous claims from 27 to 29, wherein before the application of layer C, the surface of layer B is subjected to a cleaning step, preferably by means of blasting.
31. The manufacturing method according to any of the previous claims from 23 to 30, wherein said layer C has a thickness ranging from 0.5 to 10 mm.
32. The manufacturing method according to any of the previous claims from 23 to 31, wherein said wall made by three superimposed layer constitute the plate wherein said tube bundle is inserted.
33. The manufacturing method according to any of the previous claims from 23 to 32, wherein said tube bundle is formed by bimetallic tubes, each comprising a stainless steel outer layer and an internal lining layer, in contact with the corrosive fluid, consisting of a material selected from titanium, zirconium or an alloy of one of them.
34. The manufacturing method according to any of the

previous claims 32 and 33, wherein said B layer is strength and seal welded with the said stainless steel layer of said bimetallic tube, and said C layer is seal welded with the internal lining layer of said bimetallic tube.

35. The manufacturing method according to any of the previous claims from 23 to 32, wherein said tube bundle is formed by tubes entirely made of a metal selected from titanium, zirconium and an alloy thereof.

36. The manufacturing method according to a the previous claim 35, wherein, in said plate, said layer C is strength welded with each tube of said tube bundle.

37. The manufacturing method according to any of the previous claims 35 and 36, wherein a further carbon steel layer D is placed onto said layer B, and said layer C, having a thickness of from 2 to 10 mm, is explosive clad onto said layer D.

38. A modification method of pre-existing equipment in order to obtain an apparatus according to any of the previous claims from 1 to 10, said apparatus being a tube bundle pressure apparatus comprising bimetallic tubes made of stainless steel internally lined with a metal selected from zirconium,

titanium or an alloy of said metals, wherein at least a part of the surface in contact with the process fluid is subject to strong corrosive attacks, comprising the application of an internal lining close to and above the areas effectively or potentially exposed to corrosion and optionally on the whole cavity or part of the apparatus exposed to the risk of corrosion, with the necessary metallic layers obtaining a three-layered structure consisting of:

- A) an external layer suitable for tolerating the pressure load, subject to corrosion by contact with said highly aggressive process fluid;
- B) a stainless steel intermediate layer, strength and seal welded with the stainless steel inlet of each of said bimetallic tubes forming the tube bundle;
- C) an anticorrosive lining situated on the internal surface in contact, during use, with said highly corrosive fluid, consisting of a material selected from titanium, zirconium or an alloy of one of these, seal welded with the internal lining of each of said bimetallic tubes.

39. The modification method according to claim 22, suitable for the repairing or revamping of said

pre-existing equipment.

40. The modification method according to one of the previous claims 22 or 23, effected during an ordinary maintenance intervention.

5 41. The modification method according to any of the previous claims from 22 to 24, comprising the cleaning of the whole surface of the cavity and the subsequent affixing, on the stainless steel layer, of a layer of zirconium having the desired
10 thickness, preferably from 0.5 to 3 mm, suitable seal welded with the lining of each bimetallic tube.